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This program was used to acquire the necessary optical and electronic hardware to build a versatile Ti-Sapphire laser based pulsed shaping system for applications to studies of semiconductor quantum dots for quantum computing. The system has already been used to enable the first report of spectral hole burning in self-assembled quantum dots. Future experiments will use the adaptive capability of this system to implement coherent control technique for to increase the clock speed for quantum computing applications in quantum dots.

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FINAL REPORT

Laser System for Nano-Optical Spectroscopy and Optical Manipulation of Semiconductor Quantum Dots

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Randall Laboratory, Ann Arbor, MI 48109
GRANT NUMBER: DAAD19-99-1-0031
Contract Period: 3/25/99 - 3/24/00 NCTX 3/24/01
Proposal No.: 39296-PH-RIP

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This grant was used to acquire and build new instrumentation to enable more sophisticated coherent transient and control of semiconductor quantum dots. The approach was to incorporate a laser amplifier into our Ti:Sapphire laser system and then use a pulse shaping system to provide not only arbitrary control over the electromagnetic field, but also the capability of two independently tunable optical fields.

The basic system design is shown in Fig. 1. The approach is based on the same design used by Phil Bucksbaum's group at Michigan which he has shown to be extremely affective for feedback based coherent control experiments. This system will be used in future coherent control experiments to enable faster clock speeds for in quantum computing by preserving the quality of Rabi oscillations (one-bit rotations) by compensating for optically coupling to nearby states.

The system continues to be under development, but has already been used to obtain new data. Figure 2 below shows the first report of spectral hole burning in self assembled quantum dots. Not only do we observe the spectral hole, but we also detect the clear negative going signature of the biexciton. The absence of the biexciton for cross polarized excitation (for linearly polarized selection rules) is in agreement with the selection rules. This data and related studies will be presented more thoroughly in a forthcoming progress report on ARO Grant Number DAAD19-01-1-0478

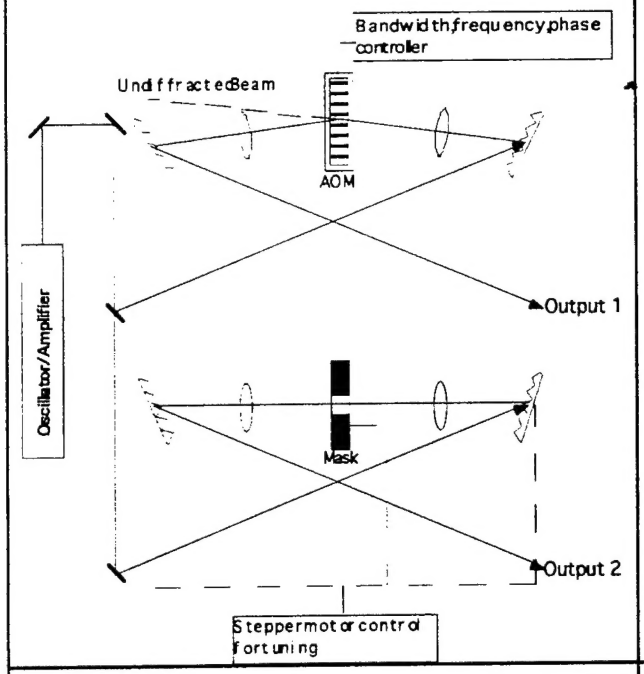

Figure 1. Schematic of basic experimental configuration for producing two independently tunable adjustable bandwidth laser pulses.

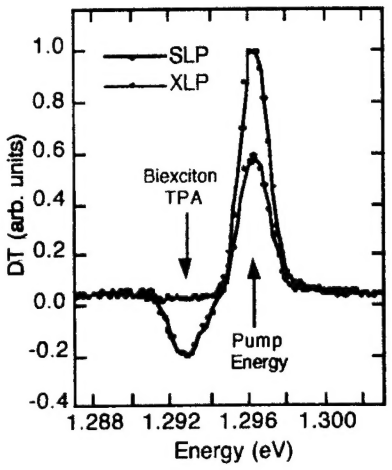

Figure: Transient spectral hole burning in an InAs quantum dot ensemble, for pump and probe having the same (SLP) or crossed (XLP) linear polarizations. The delay was +5 psec. The spectral hole is centered at the pump energy, with similar linewidth. The induced absorption in the SLP case results from biexciton two-photon absorption (TPA), giving an approximate biexciton binding energy of 3.6 meV